Benchmarking the production of audit services: an efficiency frontier approach

BENCHMARKING THE PRODUCTION OF AUDIT SERVICES
AN EFFICIENCY FRONTIER APPROACH

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ABSTRACT

To compete effectively in an increasingly competitive audit market audit firms need information on the efficiency of the audit services they offer. This study reports on the cost and labor efficiency for a sample of 114 audit engagements conducted by one of the (then) Big 6 audit firms. Estimating the efficiency of audit engagements is a form of benchmarking, of which economics oriented research has seen many applications. The application to auditing however is, as far as we know, relatively new. To determine the cost and labor efficiency of the audit engagements we employ the statistical technique of stochastic frontier estimation. Using models from the well-known and established audit fee and audit production literature we find that for our sample, audit services are produced in a cost and labor efficient manner.

Keywords: accounting and auditing, economics; audit production, cost and labor efficiency, stochastic frontier estimation

Data availability: The data used in this study are proprietary to the audit firm studied and cannot be released by the authors.

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INTRODUCTION

The audit services market is becoming increasingly competitive. To offer audit services at competitive prices, information on the costs of conducting audit engagements is essential. More specifically, given a specific level of audit quality, audit firms need to know the *minimum* amount of costs necessary to effectuate particular audit engagements. In other words, information on the cost efficiency of audit engagements is wanted. Since audit firms are professional service organizations whose most important input is human capital, the majority of the costs associated with audit engagements consist of costs for use of labor hours. This implies that audit firms also need information on (the minimum amount of) labor hours to compete effectively with other audit firms on the dimension of audit pricing.

This study investigates the cost and labor efficiency for a sample of audit engagements conducted by one of the (then) Big 6 audit firms employing an efficiency frontier technique known as stochastic frontier estimation. Using efficiency frontier techniques is a form of relative performance evaluation (RPE). In applying RPE, information about the performance of other parties is used in assessing the performance of specific parties[1] (Dopuch and Gupta 1997, 142). This is frequently termed “benchmarking”. Translated to the current study, we use information about the performance of other audits to evaluate the performance of a specific audit.

Managerial and financial accounting research, and economics oriented research in general, has shown a wide area of benchmarking and RPE applications, in public and in private sectors, in manufacturing and in service organizations, at micro (individual employees, operational processes, organizational departments and branches, entire organizations), meso (industries) and macro levels (countries). Examples include executive compensation based on RPE (e.g. Lanen and Larcker 1992), cost and productive efficiencies of banks (Sherman and

Gold 1985), cost efficiency of public schools (Dopuch and Gupta 1997), performance of local governments (de Borger and Kerstens 1996), performance of private and public utilities (Färe et al. 1985), efficiency of hospitals (Grosskopf and Valdmanis 1987), efficiency of labor use in insurance offices (Kubhamkar and Hjalmarsson 1995), and efficiency of European railway companies (Pestieau 1993).

To our knowledge, however, the application of benchmarking and RPE to auditing is relatively new. There is a substantial body of research investigating the pricing of audit services and, to a lesser extent, the production of audit services (see our discussion in the next section). All of these studies implicitly assume that audit firms produce their services in an efficient manner and thus at minimum costs, as evidenced by the statistical techniques they employ. After all, least squares regression fits a line through the center of a scatter plot, thus allowing to determine the *average* amount of audit effort needed to complete an audit for a particular client, or the *average* amount of costs incurred in conducting audits. Regression techniques, however, cannot be employed to determine the *minimum* amount of audit effort or the *minimum* amount of costs necessary to conduct an audit and are therefore unable to determine the (relative) efficiency of audit production and audit costs. The efficiency frontier techniques which we referred to earlier (and which we will discuss further in a subsequent section) *are* able to do so. Therefore we use an efficiency frontier technique to determine the (labor and cost) efficiency of audit services production.

As far as we know, only one other study has applied benchmarking and RPE to audit services. Employing a data set from the late 1980s, Dopuch et al. (2000) use two efficiency frontier techniques – the statistical technique stochastic frontier estimation and the linear programming technique data envelopment analysis – to determine the minimum amount of audit effort, disaggregated by staff level, required for the production of audit services, as well as the minimum amount of (a surrogate of) audit costs associated with this production.[2] As

Dopuch et al. (2000) indicate, studying each individual staff level separately provides information on the (in)efficiencies of labor for each of these individual staff levels. However, it does not indicate whether the mix of labor hours was efficient as well. Therefore, Dopuch et al. use (a surrogate of) audit costs, in addition to audit hours disaggregated by staff level, to investigate whether the composition of the audit team in its entirety was efficient. We follow Dopuch et al. (2000) in that we use both audit hours disaggregated by staff level and audit costs to study the efficiency of the production of audit services. However, our measure of audit costs differs from that used by Dopuch et al. (2000). As we will argue in subsequent sections, we believe our measure of audit costs presents a more accurate picture of actual audit costs incurred by the firm in conducting the audit engagements.

The remainder of this paper is organized as follows: in the following section we review prior research on audit pricing and audit production. In subsequent sections we describe the data collection, and the variables and model specification used in the study; we discuss efficiency frontier techniques in general and stochastic frontier estimation in particular; and we present the results of our study. In a final section we summarize and conclude.

PRIOR RESEARCH: AUDIT PRICING, AUDIT PRODUCTION AND THE LABOR EFFICIENCY OF AUDIT SERVICES

As stated earlier, prior research on the labor and cost efficiency of audit services is rather limited. In fact, to our knowledge, only one other study (Dopuch et al. 2000) has investigated the labor and cost efficiency of audit services. There is, however, a substantial amount of research on audit pricing and audit production on which the study by Dopuch et al. (2000) is based. Before discussing Dopuch et al. (2000), we will therefore provide a review of this research. Although our emphasis will be on audit production studies, we will discuss audit fee studies as well. The initial unavailability of data on audit production led researchers to base inferences about audit production on audit fee research. When audit production data did become available, audit production models built upon the models used in audit pricing studies. This justifies a concise discussion of audit fee studies.

Simunic (1980) was the first to develop an extensive model of audit fees. In examining the competitiveness of the audit market, he hypothesized and found factors relating to auditee size, auditee complexity, auditee asset composition, auditee industry, auditee risk and financial distress, auditor's tenure and auditor type (Big 8/6/5 vs. non-Big 8/6/5) to be associated with audit fees. Simunic's study has initiated a large stream of research replicating and extending his work. Besides assessing the competitiveness of the audit market (see e.g. Francis 1984) these studies have investigated a multitude of issues, such as reputation effects (e.g. Craswell et al. 1995), the provision of nonaudit services (e.g. Palmrose 1986b), off-peak pricing (e.g. Francis and Stokes 1986); learning over time (e.g. Chung and Lindsay 1988), price-cutting (e.g. Simon and Francis 1988), and client participation (e.g. Stein et al. 1994). Although the studies' findings are mixed with respect to some of these issues, in general the audit fee model is fairly robust across time periods, countries and sample composition, and a number of results are consistent across the majority of audit fee studies. For instance, auditee size, auditee complexity, auditee asset composition and auditee financial distress are all positively associated with audit fees. Furthermore, Big 8/6/5 auditees pay significantly higher fees than do non-Big 8/6/5 auditees.

Evidence based on audit fees will permit only indirect testing of hypotheses concerning the production of audit services. After all, an audit fee is the product of quantity (audit effort exerted by various grades of labor) and price per unit of labor category. As a result, a test based on audit fees may be confounded by the audit firms' pricing policies (O'Keefe et al. 1994, 242). Therefore, a change in audit fees may not reflect pure changes in audit production but merely changes in audit pricing. A limited amount of studies have used information on audit effort for testing hypotheses about the production of audit services. In doing so, these studies have mainly employed data on client and engagement characteristics that have been shown to be important determinants of audit fees in prior research.

An explanation of the audit production problem is important for our discussion of efficiency frontier techniques and stochastic frontier estimation in a later section. We will therefore discuss the concept of the audit production problem before we proceed to a review of studies on this subject. We base our discussion of the audit production problem on that of O'Keefe et al. (1994) and Stein et al. (1994).

A production function describes the (technical) relationship between the inputs and outputs of a production process (Coelli et al. 1998, 12). Inputs specify the amounts of resources necessary to produce a given level of output. Applied to the production of audit services, the inputs of the audit production process are the units of labor necessary to produce a given level of output.[3] As for all service organizations, the output of an audit firm is difficult to define. O'Keefe et al. (1994, 241) describe the output of the audit production process as the level of assurance provided to financial statement users that these financial statements are not materially misstated.

In their application of the audit production model, O'Keefe et al. (1994, 243-244) make the following assumptions: (1) the level of assurance produced by an audit firm is not directly observable. It is assumed that this assurance level is implied by the audit firm's brand name; (2) any particular audit firm produces a fixed level of assurance at a moment in time. That is, a firm's audit quality level is assumed to be fixed at any moment in time; (3) the client firm's structure is taken as predetermined; (4) a client firm's owners and managers will select an audit firm which will deliver the level of assurance demanded by the client firm; and (5) the audit firm operates in a competitive environment, motivating the firm to produce its output at minimum cost.

Based on these assumptions, O’Keefe et al. (1994) describe the auditor’s decision problem as a constrained cost minimization problem for a fixed level of assurance (Hackenbrack and Knechel 1997, 485). Formally, this can be written as:

$$\text{minimize } c(h, \gamma)$$

$$\text{such that } \underline{q} = p(h, \gamma)$$

with:

$c(\cdot)$ audit cost function

h vector of audit service inputs

γ vector of exogenous client firm characteristics

$\underline{q}$ level of assurance associated with the audit firm’s brand name

$p(\cdot)$ audit production function

The inclusion of client characteristics in the above cost and production functions is common for service organizations (Fuchs 1968, 194; O’Keefe et al. 1994, 244).

Assuming that an audit firm’s assurance level is fixed at a certain point in time, and that this level of assurance can in fact be produced by the audit firm in question, the optimum combination of audit services inputs **h*** at that point in time can be estimated from the following equation:

$$\mathbf{h^*} = p^{-1}(\underline{q}, \gamma)$$

Under the assumption that an audit firm operates in a competitive market, this solution implies the following minimum cost level for the fixed level of assurance $\underline{q}$:

$$c(\mathbf{h^*}, \gamma)$$

Be it implicitly or explicitly, all studies reviewed below apply the audit production problem outlined above and use the audit production equation **h*** as defined above.

Compared to audit fee studies, the number of audit production studies conducted to date is more limited. The earliest production studies use total audit hours spent on an engagement as the dependent variable and include as independent variables those client characteristics influencing audit quantity (see Palmrose 1986a, 1989; Davis et al. 1993; Davidson and Gist 1996). Generalizing the results, these studies consistently find that factors important in explaining variation in audit fees are also important in explaining variation in audit hours. A number of other production studies extend these studies by using audit hours disaggregated by staff level (O'Keefe et al. 1994; Stein et al. 1994; and Bell et al. 1994), or audit hours disaggregated by staff level and audit activity (Hackenbrack and Knechel 1997). According to O'Keefe et al. (1994, 245), the use of aggregate hours spent on engagements is inappropriate when factors have differential effects on the various types of labor. Using disaggregated hours allows to investigate whether (and which) factors impact on the amount, as well as the mix of labor resources. Again, these studies find that factors relating to auditee size, complexity and risk that were important determinants of audit fees are important determinants of audit hours as well. In addition, they find that certain size and risk measures also significantly influence the mix of labor resources.

Dopuch et al. (2000) is the only study conducted to date that, to our knowledge, explicitly investigates the issue of efficiency in the production of audit services. To the same data set used in O'Keefe et al. (1994), Stein et al. (1994) and Bell et al. (1994) they apply the efficiency frontier techniques of stochastic frontier estimation (SFE) and data envelopment analysis (DEA) to measure the relative efficiency of audit labor hours per staff level as well as (a surrogate of) audit costs.[4] As has been referred to in the Introduction and as will be argued in a later section, the characteristics and assumptions of ordinary least squares regression techniques (used by all other studies discussed above) render this technique unsuitable for detecting possible inefficiencies in the production of audit services, in contrast to efficiency frontier techniques such as SFE and DEA. The SFE and DEA results of Dopuch et al. (2000) are rather contradictory: whereas the SFE results suggest that there are no labor or cost inefficiencies in the production of audit services, the DEA results suggest the opposite. To a large extent, we believe this difference in result may be explained by the differences between the two efficiency frontier techniques. The specifics of efficiency frontier estimation will be discussed in a later section. Suffice it to state here that SFE measures the relative efficiency a production process by assuming that the error term consists of two independent sources of errors: a one-sided error (truncated from below at zero) representing inefficiency, and a symmetric error representing random variation from the so-called efficiency frontier.[5] Whereas SFE assumes that deviations from the frontier may consist of inefficiencies as well as random noise, DEA assumes that all deviations from the frontier represent inefficiencies. Therefore, application of DEA may result in more deviations from the frontier being labeled as inefficiencies than when SFE is used (Schmidt 1985-86, 304 and 319).

DATA COLLECTION, VARIABLES AND MODEL

We obtained our data from a survey among engagement partners of a (then) Big 6 audit firm. Based on an extensive review of prior audit fee and production studies (see prior section), we designed the survey instrument in cooperation with the technical department of the audit firm, which also administered the survey. The instrument–in the form of an electronic spreadsheet–was sent to the audit engagement partners of each of the firm's offices and was accompanied by a cover letter and an instruction. Prior to conducting the actual survey, instrument, cover letter and instruction were pilot tested. Some minor adjustments were made.[6]

Great care was taken to obtain high quality data. The instruction accompanying the survey instrument specified selection criteria for the engagements to be included in the sample, and contained directions for filling out the spreadsheet.

The selection criteria indicated that the engagements to be included in the sample: (1) are financial statement audits. Reviews, compilations or special assignments are not to be considered; (2) pertain to the most recent audit; (3) concern clients in for-profit sectors. Prior audit fee research has shown that fee models for not-for-profit organizations differ from those using data from profit organizations (see e.g. Baber et al. 1987; Rubin 1988; Ward et al. 1994; Sanders et al. 1995); (4) do not concern clients in the financial services industry. Again, prior studies have found that fee and production models differ significantly between financial service industry clients and clients in other industries (see Simunic 1980; Simunic 1984; Palmrose 1986a, 1986b, 1989; Turpen 1990; Stein et al. 1994). No other restrictions as to the client's industry were imposed; (5) concern publicly and privately held companies subject to a statutory audit requirement; (6) do not concern clients that are included in the Amsterdam Exchanges Index (AEX) or the Amsterdam Midkap Index (AMX). Together, these indexes are comprised of the 50 most actively traded shares on the Amsterdam Stock exchange and include companies like Heineken, KLM and Philips. Many are fairly unique in their own right, rendering these companies unsuitable for our purposes since application of RPE and benchmarking requires observations that are comparable to some extent (Dopuch and Gupta 1997, 142); (7) relate to clients that publish independent financial statements; and (8) are audits of either independent companies or subsidiaries. Holding companies should not be selected. The rationale for this last criterion is that the audit hour and audit cost data on the one hand and the data on client characteristics on the other hand need to concern one and the same entity. Audits of holding companies are often conducted in cooperation with other offices of the firm, either within the same country or abroad, or with other audit firms. In such cases, especially obtaining all relevant hour and cost data is relatively complicated and may result in inaccurate data.

The directions for filling out the questionnaire asked the partners to retrieve the requested data from the firm's internal billing records (which contains data on audit hours, internal billing rates and fees) and the firm's electronic filing system (in which all kinds of client characteristics are recorded during the performance of audits). In addition, the directions clarified which particular data were to be collected, so as to minimize ambiguities. Furthermore, the partners were told that we would not be informed about the identity of the individual clients.

Each of the 25 offices of the firm received a request to supply data on 25 audit engagements, 18 offices agreed to participate, resulting in a total of 157 responses. Of these, 114 responses are used in the analyses. Four responses are not usable because they do not meet the selection criteria discussed above[7], and 39 responses have missing values.

Table 1 shows descriptive statistics for the 114 observations used in the analyses.

[Table 1 here]

The selection of variables included in our analyses is based on a review of prior audit fee and audit production literature (see previous section) and concerns factors related to client size, client complexity, client asset composition, client risk and financial distress, quality of client internal controls, auditor's tenure, and the auditor's provision of nonaudit services.

The model specification we use in our study is also based on those used in previous audit fee and production research.[8] For audit hours, the model is as follows:

$$\ln h_j = \beta_{j0} + \beta_{j1} \ln A + \beta_{j2} \ln R + \beta_{j3} \ln L + \Sigma\, \beta_{ji}\, \gamma_i + \varepsilon_i \tag{1}$$

In this formulation, h_j represents the actual number of audit hours spent on an audit by the jth staff level, A indicates client size, R number of reports provided to the management by the auditor, L the number of client locations visited during the audit, and γ_i represents all other client characteristics as shown in Table 1.

We use a similar model for our cost function:

$$\ln c = \beta_0 + \beta_1 \ln A + \beta_2 \ln R + \beta_3 \ln L + \Sigma\, \beta_i\, \gamma_i + \varepsilon_i \tag{2}$$

where c represents the total audit costs incurred by the audit firm for a specific audit, and all other variables are defined as above. Total audit costs per engagement consist of the following components: (1) actual number of audit hours spent per staff level, times the internal hourly rate differentiated per staff level per engagement, summed over all staff levels; and (2) out-of-pocket costs (see Davis et al. 1993, 138). Our measure of audit costs differs from the standard fee mentioned in O'Keefe et al. (1994, 248) and used as a surrogate for audit costs in Dopuch et al. (2000, 8). This standard fee is described as the product of actual hours per staff level multiplied by standard billing rates, summed over all staff levels. However, we do not use standard billing rates per staff level, but the actual internal hourly rates per staff level charged to each individual audit engagement. Since our data indicate that these actual rates per staff level cover a broad range, we consider our use of differentiated billing rates to compute audit costs more accurate than that of billing rates per staff level that are equal over all engagements.[9] In addition, we also include out-of-pocket costs (representing costs like travel, lodging and meals, see Davis et al. 1993, 138) incurred per engagement in our cost measure.

EFFICIENCY MEASUREMENT TECHNIQUES AND STOCHASTIC FRONTIER ESTIMATION

As discussed earlier, a production function describes the (technical) relationship between the inputs and outputs of a production process (Coelli et al. 1998, 12). It specifies the maximum quantities of realizable output given any level of inputs, or alternatively, for any level of output the minimum quantities of inputs needed for producing (Thiry and Tulkens 1989, 22). In this context, the production function is also viewed as the frontier of the so-called production set (Pestieau 1993, 128; Greene 1997, 85). The elements that constitute this set are all the input-output combinations that are physically feasible to the producer. The frontier indicates the limits of what is achievable. Feasible productive activities that lie on the frontier are efficient, those that lie inside the production set are inefficient. The larger the distance from the frontier, the more inefficient the activity (Pestieau 1993, 130). The production frontier-function acts as a norm, serving as a base for assessing efficiency (Thiry and Tulkens 1989, 23). It is to be emphasized that this norm is relative rather than absolute: the degree of (in)efficiency of any input-output combination is evaluated relative to the most efficient observation in the data set. Therefore, the production frontier is often termed a “best practice” frontier (Greene 1997, 98).

The production function describing the relationship between inputs and outputs is called the primal function. Besides this primal function, one can also estimate the so-called dual functions of the production function: cost and profit functions. The choice for either of these two depends on the behavioral assumption one makes: cost minimization or profit maximization (Coelli et al. 1998, 22-23). As discussed in our prior research section, the audit production problem can be characterized as a cost minimization problem.

As indicated in the first section of this paper, conventional ordinary least squares regression techniques are unable to determine whether an input-output combination is (cost) efficient, and to what extent. Since these techniques fit a line through the center of a scatter plot of input-output combinations they can be used to calculate average, but not efficient, production and cost levels. So-called efficiency frontier techniques, however, can do so. The literature distinguishes along the dimensions parametric–non-parametric and deterministic–stochastic (see e.g. Schmidt 1985-86; Knox Lovell and Schmidt 1988; Thiry and Tulkens 1989; Pestieau 1993; Greene 1997).

Parametric approaches to estimating production or cost frontiers assume a particular functional form for the frontier and make use of econometric estimation methods. SFE, developed by Aigner et al. (1977) and Meeusen and van den Broeck (1977), is an example of a parametric frontier estimation technique. Non-parametric approaches do not require a-priori specification of a functional form but rather make use of the formal properties that the points in the data set should satisfy, employing mathematical programming techniques. An example of the non-parametric approach is DEA, developed by Charnes et al. (1978), which uses linear programming techniques to estimate efficiency frontiers.

A further distinction is made between deterministic and stochastic frontier estimation techniques. Deterministic techniques, such as DEA, take no account of the possible influence of measurement error, omitted variables, and other noise upon the frontier. All deviations from the frontier (i.e. the error terms) are assumed to be the result of inefficiencies. A more realistic approach is taken by stochastic frontier techniques like SFE, which accounts for two sources of errors: a one-sided error representing inefficiency, and a symmetric error representing random variation of the frontier.

In this study we use a parametric frontier technique, more specifically a stochastic frontier technique, to estimate production and cost frontiers. We prefer the stochastic to the deterministic approach because it takes account of measurement errors, omitted variables and other noise. The assumption that the error term is solely composed of inefficiency is unlikely (see Schmidt 1985-86, 308). We also prefer a parametric to a non-parametric approach. A major disadvantage of non-parametric techniques is the inability to conduct conventional tests of hypotheses (Greene 1997, 93; Coelli et al. 1998, 245). In contrast, a parametric technique does allow for statistical inference since it employs econometric estimation methods. We acknowledge the often-mentioned disadvantage of parametric techniques of the need to specify a functional form for the production and cost function (see Coelli et al. 1998, 246). However, as do Dopuch et al. (2000, 10), we feel that this is not a serious problem since the relationship between audit fees (and to a lesser extent, audit hours) and client and engagement characteristics has been studied extensively, resulting in a robust log-linear specification of this relationship. Another often-quoted disadvantage of parametric techniques concerns the need to specify a distributional form for the inefficiency term. We believe this not to be a major problem in our study, since our analyses in the subsequent section show that the results are not likely to be dependent on the distributional form of the inefficiency term.

In conventional ordinary least squares regression, the error term ε_i in the production and cost functions as defined in a prior section is assumed to consist of pure noise, being randomly distributed with mean zero and variance σ_ε^2. In contrast, and as stated, the stochastic frontier technique assumes that ε_i is composed of two sources of errors: $v_i + u_i$ The first element v_i is similar to the interpretation of ε_i in ordinary least squares regression, representing measurement error, omitted variables and other noise, and is assumed to be independent and identically distributed with mean zero and variance σ_v^2. This random error is assumed to be distributed independently of the second element, u_i, a one-sided error representing inefficiency. This latter error is also assumed to be independent and identically distributed, following a half-normal distribution (truncated from below at zero)[10] with mean zero and variance σ_u^2. Both v_i en u_i are assumed to be distributed independently of the independent variables in the frontier production or cost model.

To determine whether the stochastic frontier model is a better representation of the production process and the resulting cost structure than the ordinary least squares regression model, we need to test if there are in fact labor and/or cost inefficiencies in the models specified. This involves testing the null hypothesis H_0: $\sigma_u^2=0$ versus the alternative hypothesis H_1: $\sigma_u^2>0$. Acceptance of H_0 would mean that there are no (labor or cost) inefficiencies in the model, implying that the ordinary least squares regression model provides a valid representation of the production process or cost structure in that there are no inefficiencies present. Instead, rejection of H_0 would indicate that indeed there are inefficiencies in the production process or cost structure, leading one to conclude that the stochastic frontier model is to be preferred over the ordinary least squares regression model.

RESULTS

The following disaggregated staff levels are studied in our analyses: (1) partner; (2) manager; (3) supervisor; (4) assistant; and (5) supporting activities. The latter category differs from the first four in that in contrast to the partners, managers, supervisors and assistants, the employees performing the supporting activities are not part of the audit team. Conducting mostly secretarial and related activities, their duties are less of an audit nature than are those of the other levels. We therefore expect our model to be less suited for this category than for all other categories. We do, however, include this category in our analysis to provide a complete picture of the audit production process and the related cost structure.

Besides labor hours disaggregated by staff level, we also perform our analyses for two composite measures, total audit costs and total audit hours. A definition of total audit costs was provided in our section on data collection, variables and model. Total audit hours is simply an unweighted sum of the labor hours per staff level spent on a specific engagement.

OLS Regressions Results and Tests

Table 2 presents the results of the OLS regression of the dependent variables on the independent variables that were presented and defined in Table 1.

[Table 2 here]

Examination of pairwise correlations among the independent variables and of the variance-inflating factors (Gujarati 1995, 328) shows that multicollinearity is not a problem.[11] Since application of Breusch-Pagan tests (Greene 2000, 509-510) indicate presence of heteroscedasticity for the models for total costs, total hours, partner hours, supervisor hours and assistant hours, the t-ratios presented for these regressions are computed using White's heteroscedasticity-consistent covariance matrix estimation method.

The table shows that the models are significant at the 0.01 level, except for supporting activities. This latter result does not surprise us considering the deviant nature of the activities of this staff level compared to the other levels. The regression for supporting activities also has the lowest explanatory power of all models presented as evidenced by its adjusted R^2. All other models have an adjusted R^2 that is well inside the range of those reported by prior audit production studies (see the section on prior research for these studies). What is striking though, is that the explanatory power of models for total audit costs and for total audit hours is much higher than for the disaggregated measures. Apparently, our specification better explains the composite measures than the constituent parts of these measures.

Turning to the independent variables, we see that our results confirm prior audit production studies in that measures of client size, client complexity, client asset composition, client risk and financial distress, quality of client internal controls, auditor's tenure, and the auditor's provision of nonaudit services are determinants of total audit costs, total audit hours and at least some category of disaggregated labor hours. Also in line with prior research, client size (in the form of assets) seems to be the most important determinant of audit costs and (aggregated and disaggregated) audit hours.[12] Table 2 also shows that the results for some variables are inconsistent with our expectation in that they have a sign opposite to the one we expected (when these effects are statistically significant, they are in bold face type). For the supervisor level, an other than unqualified opinion seems to decrease rather than increase the number of audit hours spent. Also, auditor learning does not appear to take place in a consistent manner[13] as evidenced by the significant negative signs of the second year client indicator for total audit hours, and the fact that for most models the coefficients for the tenure indicators are not significantly different.[14] Finally, for the manager level, higher quality of internal controls appears to increase rather than decrease the number of audit hours. Removal of outliers identified by robust regression (Berk 1990) did not change these findings. The overall regression results after removal of outliers were qualitatively similar to those before removal of outliers.

Stochastic Frontier Estimation Results and Tests

We have estimated the stochastic frontier specification of the cost and production models using the program Frontier 4.1 (Coelli 1996). This program employs the method of maximum likelihood estimation to obtain the vector of parameters of the models.

Table 3 reports the results for the estimation of the stochastic frontier models for each of the composite measures total audit costs and total audit hours, and the disaggregated labor hours. For ease of comparison, the OLS results are presented alongside the stochastic frontier estimation (SFE) results.

[Table 3 here]

The table shows that the OLS and SFE results are virtually identical. First of all, there are essentially no differences in the intercepts and coefficient parameters and the associated levels of significance between OLS and SFE for each of the equations. Second, the test of H_0:

σ_u^2=0 versus H_1: σ_u^2>0 indicates acceptance of H_0, implying indifference between the OLS and the SFE specification of the cost and production models.[15] Taken together, these findings suggest that there are no cost and labor inefficiencies in the production of audit services, in that – at least for these particular clients of this particular audit firm at this particular point in time – these services could not have been produced for less costs and with less labor hours. Our results match the SFE results, but not the DEA results, of Dopuch et al. (2000). As discussed in an earlier section, Dopuch et al. (2000) do not find inefficiencies in the production of audit services when using SFE. In contrast, results using DEA do show inefficiencies in this production. As stated, we believe this difference between SFE and DEA results is largely due to the differences between the two frontier techniques.

Cost and labor efficient audit services fit with the representation of the audit market as (price) competitive, disciplining auditors to conduct audits efficiently. Still, we find our results surprising, considering "..(…) the complexity of the audit process, diversity in the knowledge of auditors, and the fact that client characteristics vary a great deal from engagement to engagement.(…)" (Dopuch et al. 2000).

DISCUSSION AND CONCLUSION

The aim of the current paper was to benchmark the production of audit services by investigating the cost and labor efficiency of a sample of (then) Big 6 audit engagements using the statistical technique of stochastic frontier estimation. The results show that our model specification of audit production performs in a fashion similar to those of prior audit production studies, in that (1) measures of client size, client complexity, client asset composition, client risk and financial distress, quality of client internal controls, auditor's tenure, and the auditor's provision of nonaudit services are shown to be important determinants of audit costs and audit production; and (2) client size is the single most important factor explaining audit costs and audit production. In addition, our results suggest that prior audit fee and production model specifications also provide good explanatory power for a model of audit costs, a model that to our knowledge only Davis et al. (1993) has tested[16], finding a much lower adjusted R^2.

Turning to our results for the estimation of efficiency, our findings are similar to the SFE results, but opposite to the DEA results of Dopuch et al. (2000), the only other study that to our knowledge has investigated the labor and costs efficiency of audit services, in that we find that for our sample audits are labor and cost efficient. Given the nature of the audit production process, we are surprised to find these results. Apparently, the claimed (price-)competitiveness of the audit market has disciplined the auditors into cost and labor efficiency. As a marginal but important note, it has to be stated that anecdotal evidence suggests that auditors frequently engage in underreporting of time to meet time budgets, a suggestion also confirmed by research (see Kelley and Margheim 1987, 1990; Otley and Pierce 1996; Akers et al. 1998-99). If this were also true for the auditors in our sample, our findings would suggest that hours are consistently underreported for all clients, and that the firm’s many years’ audit experience has at least rendered their audit budget efficient.

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Table 1
Descriptive statistics for 114 financial statement audits

	Mean	**Std. Dev.**	**Median**	**Minimum**	**Maximum**
Continuous variables					
Total audit costs (in NLG)	90,866.28	147,262.40	56,237.50	14,525.00	1,248,970.00
Total audit hours	477.24	631.10	346.38	79.00	5,388.00
Total partner hours	22.40	35.21	11.50	1.00	205.00
Total manager hours	56.44	132.93	27.00	2.00	1,161.00
Total supervisor hours	134.31	256.48	86.00	1.00	2,635.00
Total assistant hours	256.30	279.11	198.00	28.50	2,601.00
Total supporting hours	12.79	20.45	6.00	1.00	149.00
Assets (in NLG 000's)	190,000.00	792,000.00	32,800.00	4,633.29	6,870,000.00
Nr. of reports provided to management	1.99	1.61	2.00	1.00	12.00
Nr. of locations visited by the auditor during the audit	2.00	2.65	1.00	1.00	25.00
Foreign proportion of assets	0.04	0.15	0.00	0.00	1.00
Leverage (Long term liabilities/Total assets)	0.12	0.17	0.03	0.00	0.82
(Receivables + Inventory)/Total assets	0.56	0.26	0.59	0.04	1.91 [#]
Profit margin (Net result/Total sales)	0.04	0.08	0.03	-0.33	0.51
Nonaudit fee/audit fee	0.46	0.91	0.16	0.00	6.20
Categorical variables					
Opinion type: (0,1), where 1 indicates other than unqualified opinion	0.05	0.22	0.00	0.00	1.00
First year client: (0,1), where 1 indicates a first year client	0.02	0.13	0.00	0.00	1.00
Second year client: (0,1), where 1 indicates a second year client	0.04	0.21	0.00	0.00	1.00
Third year client: (0,1), where 1 indicates a third year client	0.05	0.22	0.00	0.00	1.00
Fourth year client: (0,1), where 1 indicates a fourth year client	0.04	0.21	0.00	0.00	1.00
Inherent risk: (0,1), where 1 indicates greater than average risk	0.11	0.32	0.00	0.00	1.00
Control quality : (0,1), where 1 indicates higher than average quality	0.61	0.49	1.00	0.00	1.00
Loss in last two years: (0,1) where 1 indicates an operating loss in the last two years	0.11	0.31	0.00	0.00	1.00
Public: (0,1), where 1 indicates a public company	0.18	0.38	0.00	0.00	1.00

[#] In a number of cases cash had a negative sign, causing the ratio (Receivables + inventory)/Total assets to exceed one.

Table 2

OLS regression of (natural logs of) total audit costs, total audit hours and disaggregate audit hours on client characteristics for 114 financial statement audits

Independent variables:	Expect. sign	Total costs[1]		Total hours[1]		Partner hours[1]		Manager hours		Supervisor hours[1]		Assistant hours[1]		Supporting hours	
		coeff.	*t-ratio*	*coeff.*	*t-ratio*	*coeff.*	*t-ratio*	*coeff.*	*t-ratio*	*Coeff.*	*t-ratio*	*coeff.*	*t-ratio*	*coeff.*	*t-ratio*
Intercept	?	-- [2]	-- [2] ***	0.965	1.231	-1.315	-0.543	-6.501	-2.524 **	-3.733	-1.475	1.660	1.501	-3.334	-1.538
Assets (natural log)	+	0.322	6.930 ***	0.268	5.687 ***	0.206	1.347 *	0.494	3.353 ***	0.410	2.633 ***	0.196	2.925 ***	0.323	2.604 ***
Nr. of reports (natural log)	+	0.209	2.122 ***	0.194	1.993 **	0.186	0.798	0.300	0.875	-0.075	-0.293	0.174	1.331 *	0.134	0.464
Nr. of locations (natural log)	+	0.292	3.446 ***	0.287	3.429 ***	0.239	1.235	0.810	2.811 ***	0.321	1.312 *	0.253	2.357 ***	0.029	0.120
Opinion type	+	0.001	0.008	-0.070	-0.476	-0.278	-0.679	1.458	1.839 **	**-1.481**	**-1.789** *	-0.086	-0.312	-0.376	-0.564
Foreign proportion of assets	+	0.584	1.488 *	0.534	1.338 *	1.826	1.979 **	2.033	1.344 *	-0.304	-0.195	0.415	0.710	-1.273	-1.000
Leverage	+	-0.331	-1.095	-0.235	-0.822	0.582	0.900	-0.458	-0.428	1.024	1.409 *	-0.242	-0.661	-0.678	-0.754
First year client	+	-0.249	-1.163	-0.070	-0.334	**-0.832**	**-2.701** ***	-0.787	-0.618	-1.442	-1.487	0.297	1.409 *	0.373	0.348
Second year client	+	-0.391	-1.482	**-0.453**	**-1.714** *	-0.204	-0.596	-0.163	-0.206	-0.754	-1.105	-0.297	-1.227	-0.453	-0.680
Third year client	+	-0.056	-0.356	0.042	0.263	-0.082	-0.200	-0.159	-0.227	0.350	1.181	0.179	0.880	0.363	0.616
Fourth year client	+	0.370	1.342 *	0.318	1.191	0.709	1.747 **	-0.309	-0.388	0.669	1.863 **	0.256	0.823	0.130	0.195
(Receivables + Inventory)/Total assets	+	-0.005	-0.031	-0.027	-0.155	-0.342	-0.724	-0.358	-0.475	1.198	2.089 **	-0.187	-0.761	-0.257	-0.407
Profit margin	-	-1.185	-1.349 *	-1.149	-1.295 *	-3.172	-2.075 **	-1.920	-0.671	-6.095	-2.751 ***	0.157	0.141	-0.070	-0.029
Nonaudit fee/audit fee	-	-0.086	-1.361 *	-0.064	-0.986	-0.019	-0.199	-0.125	-0.706	0.062	0.711	-0.053	-0.746	-0.281	-1.894 **
Inherent risk	+	0.159	1.337 *	0.163	1.336 *	0.474	1.360 *	0.051	0.094	0.092	0.259	0.052	0.238	0.210	0.462
Control quality	-	0.097	1.109	0.085	0.968	0.075	0.340	**0.586**	**1.780** *	0.045	0.150	0.123	1.096	-0.460	-1.661 **
Loss in last two years	+	0.240	2.270 **	0.255	2.259 **	-0.124	-0.286	-0.284	-0.476	0.427	1.100	0.429	2.613 ***	0.072	0.144
Public	+	0.017	0.128	-0.017	-0.138	0.357	1.250	-0.067	-0.143	0.091	0.211	0.042	0.272	-0.213	-0.538
Overall F-test		16.98 ***		13.77 ***		19.58 ***		3.90 ***		6.39 ***		7.67 ***		1.13	
Adjusted R^2		0.75		0.69		0.27		0.30		0.27		0.44		0.02	

[1] t-statistics are calculated using White's correction for heteroskedasticity
[2] Intercept deleted at the request of the firm providing our data
Significance: * p <.10 level , ** p <.05 level, *** p <.01 level (tested one or two tailed, where appropriate)
Note: coefficients and t-ratios that have a sign opposite to its predicted sign and that are significant at the above-indicated levels are in bold face.

Table 3

Efficiency of total audit costs, total audit hours and disaggregate audit hours for 114 financial statement audits

Panel A: total audit costs

Dependent variable: natural log of total audit costs Independent variables:	Expected sign	OLS[1]		SFE	
		coefficient	*t-ratio*	*coefficient*	*t-ratio*
Intercept	?	--[2]	--[2] ***	--[2]	--[2] ***
Assets (natural log)	+	0.322	6.930 ***	0.322	9.801 ***
Nr. of reports (natural log)	+	0.209	2.122 ***	0.209	2.738 ***
Nr. of locations (natural log)	+	0.292	3.446 ***	0.292	4.543 ***
Opinion type	+	0.001	0.008	0.001	0.007
Foreign proportion of assets	+	0.584	1.488 *	0.584	1.699 **
Leverage	+	-0.331	-1.095	-0.331	-1.393
First year client	+	-0.249	-1.163	-0.249	-0.875
Second year client	+	-0.391	-1.482	**-0.391**	**-2.201** **
Third year client	+	-0.056	-0.356	-0.056	-0.355
Fourth year client	+	0.370	1.342 *	0.370	2.080 **
(Receivables + Inventory)/Total assets	+	-0.005	-0.031	-0.005	-0.032
Profit margin	-	-1.185	-1.349 *	-1.185	-1.808 **
Nonaudit fee/audit fee	-	-0.086	-1.361 *	-0.086	-2.202 **
Inherent risk	+	0.159	1.337 *	0.159	1.326 *
Control quality	-	0.097	1.109	0.097	1.314
Loss in last two years	+	0.240	2.270 **	0.240	1.801 **
Public	+	0.017	0.128	0.017	0.161
Overall F-test		16.98 ***			
Adjusted R^2		0.75			
Log likelihood constant only		-130.781		-125.031	
Log likelihood model		-43.291		-43.291	
Likelihood ratio test statistic		174.980 ***		163.480 ***	
Log likelihood OLS model		-43.291			
Log likelihood SFE model		-43.291			
Likelihood ratio test statistic OLS vs. SFE[3]		0.000			

Table 3-*continued*

Panel B: total audit hours

Dependent variable: natural log of total audit hours Independent variables:	Expected sign	OLS[1] *coefficient*	*t-ratio*	SFE *coefficient*	*t-ratio*
Intercept	?	0.965	1.231	0.963	1.286
Assets (natural log)	+	0.268	5.687 ***	0.268	8.263 ***
Nr. of reports (natural log)	+	0.194	1.993 **	0.194	2.556 ***
Nr. of locations (natural log)	+	0.287	3.429 ***	0.287	4.493 ***
Opinion type	+	-0.070	-0.476	-0.070	-0.400
Foreign proportion of assets	+	0.534	1.338 *	0.534	1.622 *
Leverage	+	-0.235	-0.822	-0.235	-1.018
First year client	+	-0.070	-0.334	-0.070	-0.249
Second year client	+	**-0.453**	**-1.714** *	**-0.453**	**-2.584** **
Third year client	+	0.042	0.263	0.042	0.269
Fourth year client	+	0.318	1.191	0.318	1.811 **
(Receivables + Inventory)/Total assets	+	-0.027	-0.155	-0.027	-0.161
Profit margin	-	-1.149	-1.295 *	-1.149	-1.870 **
Nonaudit fee/audit fee	-	-0.064	-0.986	-0.064	-1.657 *
Inherent risk	+	0.163	1.336 *	0.163	1.365 *
Control quality	-	0.085	0.968	0.085	1.161
Loss in last two years	+	0.255	2.259 **	0.255	1.938 **
Public	+	-0.017	-0.138	-0.017	-0.165
Overall F-test		13.77 ***			
Adjusted R^2		0.69			
Log likelihood constant only		-118.966		-114.728	
Log likelihood model		-42.569		-42.569	
Likelihood ratio test statistic		152.795 ***		144.319 ***	
Log likelihood OLS model		-42.569			
Log likelihood SFE model		-42.569			
Likelihood ratio test statistic OLS vs. SFE[3]		0.000			

Table 3-*continued*

Panel C: partner hours

Dependent variable: natural log of partner hours Independent variables:	Expected sign	OLS[1]		SFE	
		coefficient	*t-ratio*	*coefficient*	*t-ratio*
Intercept	?	-1.315	-0.543	-1.317	-0.910
Assets (natural log)	+	0.206	1.347 *	0.206	2.872 ***
Nr. of reports (natural log)	+	0.186	0.798	0.186	0.959
Nr. of locations (natural log)	+	0.239	1.235	0.239	1.506 *
Opinion type	+	-0.278	-0.679	-0.278	-0.597
Foreign proportion of assets	+	1.826	1.979 **	1.826	2.431 ***
Leverage	+	0.582	0.900	0.582	0.911
First year client	+	**-0.832**	**-2.701** ***	-0.832	-1.018
Second year client	+	-0.204	-0.596	-0.204	-0.471
Third year client	+	-0.082	-0.200	-0.082	-0.196
Fourth year client	+	0.709	1.747 **	0.709	1.626 *
(Receivables + Inventory)/Total assets	+	-0.342	-0.724	-0.342	-0.787
Profit margin	-	-3.172	-2.075 **	-3.172	-2.436 ***
Nonaudit fee/audit fee	-	-0.019	-0.199	-0.019	-0.193
Inherent risk	+	0.474	1.360 *	0.474	1.535 *
Control quality	-	0.075	0.340	0.075	0.406
Loss in last two years	+	-0.124	-0.286	-0.124	-0.366
Public	+	0.357	1.250	0.357	1.362 *
Overall F-test		19.58 ***			
Adjusted R^2		0.27			
Log likelihood constant only		-175.388		-175.388	
Log likelihood model		-148.328		-148.328	
Likelihood ratio test statistic		54.119 ***		54.119 ***	
Log likelihood OLS model		-148.328			
Log likelihood SFE model		-148.328			
Likelihood ratio test statistic OLS vs. SFE[3]		0.000			

Table 3-*continued*

Panel D: manager hours

Dependent variable: natural log of manager hours Independent variables:	Expected sign	OLS *coefficient*	*t-ratio*	SFE *coefficient*	*t-ratio*
Intercept	?	-6.501	-2.524 **	-6.511	-2.197 **
Assets (natural log)	+	0.494	3.353 ***	0.494	3.874 ***
Nr. of reports (natural log)	+	0.300	0.875	0.300	0.965
Nr. of locations (natural log)	+	0.810	2.811 ***	0.810	3.079 ***
Opinion type	+	1.458	1.839 **	1.458	1.982 **
Foreign proportion of assets	+	2.033	1.344 *	2.033	1.561 *
Leverage	+	-0.458	-0.428	-0.458	-0.466
First year client	+	-0.787	-0.618	-0.787	-0.719
Second year client	+	-0.163	-0.206	-0.163	-0.227
Third year client	+	-0.159	-0.227	-0.159	-0.246
Fourth year client	+	-0.309	-0.388	-0.309	-0.427
(Receivables + Inventory)/Total assets	+	-0.358	-0.475	-0.358	-0.535
Profit margin	-	-1.920	-0.671	-1.920	-0.797
Nonaudit fee/audit fee	-	-0.125	-0.706	-0.125	-0.775
Inherent risk	+	0.051	0.094	0.051	0.098
Control quality	-	**0.586**	**1.780** *	**0.586**	**1.949** *
Loss in last two years	+	-0.284	-0.476	-0.284	-0.524
Public	+	-0.067	-0.143	-0.067	-0.158
Overall F-test		3.90 ***			
Adjusted R^2		0.30			
Log likelihood constant only		-234.550		-234.550	
Log likelihood model		-204.592		-204.592	
Likelihood ratio test statistic		59.916 ***		59.916 ***	
Log likelihood OLS model		-204.592			
Log likelihood SFE model		-204.592			
Likelihood ratio test statistic OLS vs. SFE[3]		0.000			

Table 3-*continued*

Panel E: supervisor hours

Dependent variable: natural log of supervisor hours Independent variables:	Expected sign	OLS[1] *coefficient*	 *t-ratio*	SFE *coefficient*	 *t-ratio*
Intercept	?	-3.733	-1.475	-3.735	-1.623
Assets (natural log)	+	0.410	2.633 ***	0.410	3.953 ***
Nr. of reports (natural log)	+	-0.075	-0.293	-0.075	-0.280
Nr. of locations (natural log)	+	0.321	1.312 *	0.321	1.440 *
Opinion type	+	**-1.481**	**-1.789** *	**-1.481**	**-2.464** **
Foreign proportion of assets	+	-0.304	-0.195	-0.305	-0.268
Leverage	+	1.024	1.409 *	1.024	1.276
First year client	+	-1.442	-1.487	-1.442	-1.581
Second year client	+	-0.754	-1.105	-0.754	-1.271
Third year client	+	0.350	1.181	0.350	0.634
Fourth year client	+	0.669	1.863 **	0.669	1.091
(Receivables + Inventory)/Total assets	+	1.198	2.089 **	1.198	2.076 **
Profit margin	-	-6.095	-2.751 ***	-6.095	-2.914 ***
Nonaudit fee/audit fee	-	0.062	0.711	0.062	0.456
Inherent risk	+	0.092	0.259	0.092	0.222
Control quality	-	0.045	0.150	0.045	0.178
Loss in last two years	+	0.427	1.100	0.427	0.925
Public	+	0.091	0.211	0.091	0.242
Overall F-test		6.39 ***			
Adjusted R^2		0.27			
Log likelihood constant only		-213.289		-213.289	
Log likelihood model		-185.970		-185.970	
Likelihood ratio test statistic		54.638 ***		54.638 ***	
Log likelihood OLS model		-185.970			
Log likelihood SFE model		-185.970			
Likelihood ratio test statistic OLS vs. SFE[3]		0.000			

Table 3-*continued*

Panel F: assistant hours

Dependent variable: natural log of assistant hours Independent variables:	Expected sign	OLS[1]		SFE	
		coefficient	*t-ratio*	*coefficient*	*t-ratio*
Intercept	?	1.660	1.501	1.659	1.678 *
Assets (natural log)	+	0.196	2.925 ***	0.196	4.511 ***
Nr. of reports (natural log)	+	0.174	1.331 *	0.174	1.708 **
Nr. of locations (natural log)	+	0.253	2.357 ***	0.253	2.958 ***
Opinion type	+	-0.086	-0.312	-0.086	-0.361
Foreign proportion of assets	+	0.415	0.710	0.415	0.916
Leverage	+	-0.242	-0.661	-0.242	-0.764
First year client	+	0.297	1.409 *	0.297	0.743
Second year client	+	-0.297	-1.227	-0.297	-1.274
Third year client	+	0.179	0.880	0.179	0.863
Fourth year client	+	0.256	0.823	0.256	1.079
(Receivables + Inventory)/Total assets	+	-0.187	-0.761	-0.187	-0.830
Profit margin	-	0.157	0.141	0.157	0.192
Nonaudit fee/audit fee	-	-0.053	-0.746	-0.053	-1.016
Inherent risk	+	0.052	0.238	0.052	0.327
Control quality	-	0.123	1.096	0.123	1.259
Loss in last two years	+	0.429	2.613 ***	0.429	2.445 ***
Public	+	0.042	0.272	0.042	0.304
Overall F-test		7.67 ***			
Adjusted R^2		0.44			
Log likelihood constant only		-118.442		-118.064	
Log likelihood model		-75.629		-75.629	
Likelihood ratio test statistic		85.626 ***		84.870 ***	
Log likelihood OLS model		-75.629			
Log likelihood SFE model		-75.629			
Likelihood ratio test statistic OLS vs. SFE[3]		0.000			

Table 3-*continued*

Panel G: supporting hours

Dependent variable: natural log of supporting hours Independent variables:	Expected sign	OLS *coefficient*	*t-ratio*	SFE *coefficient*	*t-ratio*
Intercept	?	-3.334	-1.538	-3.340	-1.542
Assets (natural log)	+	0.323	2.604 ***	0.323	3.311 ***
Nr. of reports (natural log)	+	0.134	0.464	0.134	0.508
Nr. of locations (natural log)	+	0.029	0.120	0.029	0.130
Opinion type	+	-0.376	-0.564	-0.376	-0.622
Foreign proportion of assets	+	-1.273	-1.000	-1.273	-1.164
Leverage	+	-0.678	-0.754	-0.678	-0.859
First year client	+	0.373	0.348	0.373	0.406
Second year client	+	-0.453	-0.680	-0.453	-0.743
Third year client	+	0.363	0.616	0.363	0.682
Fourth year client	+	0.130	0.195	0.130	0.214
(Receivables + Inventory)/Total assets	+	-0.257	-0.407	-0.257	-0.458
Profit margin	-	-0.070	-0.029	-0.070	-0.034
Nonaudit fee/audit fee	-	-0.281	-1.894 **	-0.281	-2.072 **
Inherent risk	+	0.210	0.462	0.210	0.496
Control quality	-	-0.460	-1.661 **	-0.460	-1.812 **
Loss in last two years	+	0.072	0.144	0.072	0.157
Public	+	-0.213	-0.538	-0.213	-0.594
Overall F-test		1.13			
Adjusted R^2		0.02			
Log likelihood constant only		-195.291		-195.183	
Log likelihood model		-184.920		-184.920	
Likelihood ratio test statistic		20.742		20.526	
Log likelihood OLS model		-184.920			
Log likelihood SFE model		-184.920			
Likelihood ratio test statistic OLS vs. SFE[3]		0.000			

[1] t-statistics are calculated using White's correction for heteroskedasticity

[2] Intercept deleted at the request of the firm providing our data

[3] This test statistic is asymptotically distributed as a mixed χ^2-distribution with degrees of freedom equal to the number of restrictions (in this case one). For α=0.05, the critical value is 2.71 (Coelli et al. 1998. See Kodde and Palm (1986) for the specific critical values).

Significance: * p <.10 level , ** p <.05 level, *** p <.01 level (tested one or two tailed, where appropriate)

Note: coefficients and t-ratios that have a sign opposite to its predicted sign and that are significant at the above-indicated levels are in bold face.

Endnotes

[1] The term “parties” should be interpreted in a very broad sense. RPE has been applied to individuals, teams, organization units and departments, firms, districts, countries and many other cases.

[2] A discussion of this paper is provided in the next section.

[3] O’Keefe et al (1994) indicate that they do not include capital inputs in their model of audit production “..(…)..because we believe that these are of second-order importance.(…)” (O’Keefe et al. 1994, 245).

[4] As stated earlier, we believe the measure of audit costs used in the current study presents a more accurate picture of the actual audit costs incurred by the audit firm in conducting audit engagements than does the measure of costs used by Dopuch et al. (2000). We will elaborate on this issue in a later section.

[5] In contrast, ordinary least squares regression techniques assume that the error term consists of random noise only and, as stated earlier, are therefore unable to detect possible inefficiencies.

[6] The data that were collected during this pilot test are not included in the final data set used in the current study.

[7] One response concerned an audit for consolidation purposes, another was a review, a third was a compilation and a fourth was a holding company.

[8] These model specifications are “…(..) motivated by three basic issues: (1) to highlight the crucial role of client size as a determinant of audit effort, (2) to linearize the relationship between labor hours (or audit fees) and client size; and (3) to reduce heteroscedasticity. (…)” (Hackenbrack and Knechel 1997, 485).

[9] As Dopuch et al. (2000, 8) themselves indicate, a weakness of their surrogate (i.e. standard fees) is that the level of costs and standard fees may vary geographically.

[10] Alternative, more general distributions have been specified, such as the truncated normal distribution. This distribution is a generalization of the half normal distribution in that it is obtained by truncating the normal distribution at zero. It has a mean μ and variance σ_u^2. In the case where μ=0, the truncated-normal is equal to the half-normal

…continued

distribution (see Coelli et al. 1998, 200). According to Greene (1997, 104), despite the availability of alternative distributional forms, most empirical applications of the stochastic frontier technique have used the half-normal distribution for u_i. The results we report in this paper are for models with the half-normal distribution. However, we have also tested our model using the truncated-normal distribution, and we obtained results that are virtually identical to those using the half-normal distribution, suggesting the results are independent of our choice of the distributional form of u_i.

[11] These statistics are not presented here to save space.

[12] In fact, a regression of total costs, total audit hours, partner hours, manager hours, supervisor hours, assistant hours and supporting hours on (the natural log of) total assets yields an R^2 of 0.65, 0.59, 0.25, 0.28, 0.19, 0.40, and 0.07 respectively. All these models are significant at the 0.01 level (F-test). This confirms prior studies, "..(…)..which have shown that client size alone can explain more that 50 percent of cross-sectional variability in audit fee.(…)" (Hackenbrack and Knechel 1997, 496).

[13] Should auditor learning occur, the signs of the year client indicators are positive and ordered as follows: first year client > second year client > third year client > fourth year client (see O'Keefe et al. 1994, 253).

[14] These results are not reported here to save space.

[15] These tests are performed as one-sided generalized likelihood-ratio tests (Coelli et al. 1998, 191) and are reproduced in the bottom of each panel.

[16] As discussed earlier, the surrogate cost measure used by Dopuch et al. (2000) differs from the (we believe more accurate) measure of audit costs that we use in the current study.